

Records of *Ixodes pomeranzevi* Serdyukova, 1941 (Acari: Ixodidae) from small mammals in northern Gyeonggi and Gangwon Provinces, Republic of Korea

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Abstract

During 2008, small mammals were captured and examined for ticks at Chipori (Gangwon Province) and Nightmare (Gyeonggi Province) Ranges near the Demilitarized Zone, Republic of Korea (ROK). *Ixodes nipponensis* Kitaoka and Saito (75 nymphs, 835 larvae) was collected from *Apodemus agrarius* (Pallas), *Micromys minutus* (Pallas), and *Crocidura lasiura* Dobson, while *Ixodes pomeranzevi* Serdyukova (2 females, 4 nymphs) was collected only from *A. agrarius*. Separately, *I. pomeranzevi* (15 females, 5 nymphs, 24 larvae) was collected from *Tamias sibiricus* (Laxmann) near Bidulginang Falls (Gyeonggi Province). This is the first record of *I. pomeranzevi* from *Apodemus agrarius* in the ROK.

Key words: *Ixodes pomeranzevi*, *Ixodes nipponensis*, hosts, distribution, seasonality

Introduction

Ixodes pomeranzevi Serdyukova, 1941 was first described from *Myodes regulus* (Thomas) (= *Myodes* (formerly *Clethrionomys*) *rufocanus* (Sundevall) of many authors) collected at Komarovskii Preserve (Primorsk Territory), Russian Far Eastern Region. Other surveys reported *I. pomeranzevi* collected from the southern Primorsk Territory (Pomerantzev 1946; Slonov 1963; Emel'yanova 1967; Filippova 1967; Khudyakov 1968), with most collection sites in the Ussuri Forest region of Russia (Filippova 1984; Okulova *et al.* 1986). In China, Teng (1973) reported *I. pomeranzevi* from Gansu and Shanxi Provinces, but his determinations are in doubt (Robbins & Keirans 1992). In Korea, U.S. military personnel listed *I. pomeranzevi* in military reports from *M. regulus* (Jeju Island), *Tamias sibiricus* (Laxmann) (Wonju, Gangwon Province; Bupyeong-ri, Namyangju-si, Gyeonggi Province), and *Tscherskia* (= *Cricetulus*) *triton* (de Winton) (Daegu) (Robbins & Keirans 1992) (Table 1). This report summarizes the known distribution of *I. pomeranzevi* in the Republic of Korea and presents a new host record, *Apodemus agrarius* (Pallas).

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TABLE 1. Collection data for *Ixodes pomeranzevi* from published literature and recent surveys.

Host	Date	Location	Country	Latitude/ Longitude	Number Animals	Number Ticks	Reference
<i>Myodes regulus</i>	13-Jun-1939(F), 3-Jun-1939(N)	Komarovskii Preserve, Komandorskie Islands, Russian Far Eastern Region	Primorsk, Russia	43°48'N, 131°59'E	2	2	Serdyukova 1941
<i>Apodemus agrarius</i> , <i>A.</i> <i>peninsulæ</i> , <i>A. speciosus</i> , <i>Eriataceus europaeus</i> , <i>Microtus</i> <i>fortis</i> , <i>Myodes regulus</i> , <i>M.</i> (as <i>Clethrionomys) rutilus</i> , <i>Rattus</i> <i>norvegicus</i> , <i>Sorex araneus</i> , <i>Tamias sibiricus</i>	1946-1968	Ussuri Forest	Southern Primorsk, Russia	-	-	-	Pomerantzev 1946, Slonov 1961, 1963, Emel'yanova 1967, Filippova 1967, Khudyakov 1968,
<i>Apodemus agrarius</i> , <i>A.</i> <i>speciosus</i> , <i>Microtus fortis</i> , <i>Myodes regulus</i> , <i>M.</i> (as <i>Clethrionomys) rutilus</i> , <i>Tamias</i> <i>sibiricus</i>	1973-1975	Central Sikhote-Alin's Range (Kavalerovo, Dal'negorskoe, Chuguevka and Spassk region)	Primorsk, Russia	-	-	5F, 5N, 95L	Kolonin & Bolotin 1977
<i>Tamias sibiricus</i> <i>Vulpes vulpes</i>	1973	Gansu and Shanxi Provinces	North-Central China	-	1 1	1F 2F	Teng 1973
<i>Tscherskia triton</i>	18-Jan-1968	Jeju Island	Korea	33°20'N, 126°30'E	1	5N, 6L	Robbins & Keirans 1992
<i>Tamias sibiricus</i>	5-May-1968	Wonju, Gangwon Province	Korea	37°21'N, 127°58'E	1	1L	Robbins & Keirans 1992
<i>Myodes regulus</i>	5-Jan-1968	Daegu	Korea	35°52'N, 128°35'E	1	2L	Robbins & Keirans 1992
<i>Tamias sibiricus</i>	23-May-1955	Bupyeong-ri, Jinjeop-eup, Namyangju-si, Gyeonggi Province	Korea	37°45'N, 127°10'E	1	2N	Robbins & Keirans 1992
<i>Apodemus agrarius</i>	12-Feb-2008	Chipori Range, near Chipo-ri, Galmal-eup, Cheorwon-gun, Gangwon Province	Korea	38°08'09"N, 127°19'12"E	2	2N	H.C. Kim, Collector
<i>Apodemus agrarius</i>	12-Mar-2008	Nightmare Range, near Topyeong-ri, E-dong-myeon, Pocheon-si, Gyeonggi Province	Korea	38°03'13"N, 127°21'18"E	1	1F, 1N	H.C. Kim, Collector
<i>Tamias sibiricus</i>	20-Mar-2008	Bidulginang Falls, Daehoesan- ri, Yeongbuk-myeon, Pocheon- si, Gyeonggi Province	Korea	38°04'47"N, 127°13'03"E	1	15F, 5N, 24L	J.H. Kim & Y.S. Jo, Collectors
<i>Apodemus agrarius</i>	16-Apr-2008	Nightmare Range, near Topyeong-ri, E-dong-myeon, Pocheon-si, Gyeonggi Province	Korea	38°03'13"N, 127°21'18"E	2	1F, 1N	H.C. Kim, Collector

Materials and methods

Survey area

Rodent-borne disease surveillance was conducted at Chipori (Gangwon Province) and Nightmare (Gyeonggi Province) Ranges, near the Demilitarized Zone (DMZ), from January through November 2008. Chipori Range is situated in a broad valley at an elevation of approximately 150 m, while Nightmare Range is situated in a narrow mountain valley bordered by forested hillsides at an elevation of approximately 500 m. Both training sites are utilized by the ROK and U.S. militaries for mechanized maneuver operations and firing Abrams and K-16 tanks, mechanized and towed artillery (e.g., 105 and 155 howitzers), and mortars. Small mammal survey sites were selected adjacent to maneuver and firing positions and training site perimeters because they provided habitat (vegetative ground cover and food) for small mammals, and trapping operations did not interfere with military training activities.

Tick collections

Each trap line consisted of 25 Sherman traps (7.7 x 9 x 23 cm aluminum folding traps; H.B. Sherman, Tallahassee, FL) that were baited with peanut butter placed between two saltine crackers. The traps were set along established trap lines at 4–5 m intervals during daylight hours (1000–1800 hrs) and collected the following morning (0830–1100 hrs), as described by O’Guinn *et al.* (2008). Cotton balls (3–4) were added to each trap during the spring and winter trapping periods when temperatures were often <0°C so that animals would retain heat and attached ectoparasites. Traps positive for small mammals were numbered sequentially, placed in a secure plastic shipping container, and transported to Korea University, where the mammals were euthanized in accordance with an approved animal use protocol (Korea University, Seoul), identified to species, and given a unique identification number. Ticks were carefully removed with forceps, placed individually in cryovials containing 100% ethyl alcohol, and labeled with a unique identification number that corresponded to the small mammal collection data. Ticks were sent to the 5th Medical Detachment, 168th Multifunctional Battalion, 65th Medical Brigade, Yongsan Army Garrison, Seoul, where they were identified to species and developmental stage under a stereomicroscope using standard keys and current nomenclature (Yamaguti *et al.* 1971; Robbins & Keirans 1992; Horak *et al.* 2002). Tick identifications were confirmed by Dr. Richard G. Robbins, Armed Forces Pest Management Board, Silver Spring, MD, and 2 nymphal voucher specimens (accession numbers 300709 and 300710) from *A. agrarius* (Aa-08-123 and Aa-08-125) have been deposited in the Division of Entomology, Peabody Museum of Natural History, Yale University, New Haven, CT, USA.

Results

A total of 541 small mammals representing 8 species were captured at Chipori and Nightmare Ranges and examined for the presence of ticks. *Apodemus agrarius* (84.7%, n= 458) was the most frequently collected small mammal, followed by *Crocidura lasiura* Dobson (7.2%, n= 39), *Myodes regulus* (3.9%, n= 21), and *Micromys minutus* (Pallas) (2.6%, n= 14). *Apodemus peninsulae* (Thomas), *Mus musculus* Linnaeus, *Microtus fortis* Büchner, and *Tamias sibiricus* (separate collection) accounted for <1.0% of all mammals collected (Table 2).

Ixodes nipponensis Kitaoka and Saito, 1967 (larvae and nymphs) was the most frequently collected tick on small mammals (94.8% of total); *I. pomeranzevi* (5.2%) accounted for the remainder. *Apodemus agrarius* had the highest infestation rate (25.3%), followed by *M. minutus* (14.3%), and *C. lasiura* (7.7%) (Table 2). *Ixodes nipponensis* was collected from *A. agrarius*, *C.*

lasiura, and *M. minutus* only at Nightmare Range (>500 m), while *I. pomeranzevi* was collected from *A. agrarius* at Chipori (2 nymphs) and Nightmare (2 females, 2 nymphs) Ranges and, in a separate collection, from *T. sibiricus* (15 females, 5 nymphs, 24 larvae) captured near Bidulginang Falls, Daehoesan-ri, Yeongbuk-myeon, Pocheon-si, Gyeonggi Province (90 m) (Table 3). Based on our collections and those in the literature, the distribution of *I. pomeranzevi* appears to extend from Jeju Island (southwest of the ROK mainland) to northern Gyeonggi and Gangwon Provinces near the DMZ that separates North and South Korea (Fig. 1).

TABLE 2. Numbers of *Ixodes nipponensis* and *Ixodes pomeranzevi* collected from small mammals captured using Sherman traps at Chipori Range, Gangwon Province, and Nightmare Range and Bidulginang Falls,^a Gyeonggi Province, Republic of Korea, 2008.

Host/Species	Small mammals collected	Small mammals w/ticks	<i>I. nipponensis</i>		<i>I. pomeranzevi</i>				TOTAL
			Larvae	Nymphs	Larvae	Nymphs	Males	Females	
<i>Apodemus agrarius</i>	458	116 (25.3) ^b	731 (6.3) ^c	73 (0.6) ^c	0	4 (<0.1) ^c	0	2 (<0.1) ^c	810 (7.0) ^c
<i>Apodemus peninsulae</i>	2	0	0	0	0	0	0	0	0
<i>Mus musculus</i>	3	0	0	0	0	0	0	0	0
<i>Microtus fortis</i>	3	0	0	0	0	0	0	0	0
<i>Micromys minutus</i>	14	2 (14.3)	0	2 (1.0)	0	0	0	0	2 (1.0)
<i>Myodes regulus</i>	21	0	0	0	0	0	0	0	0
<i>Crocidura lasiura</i>	39	3 (7.7)	104 (34.7)	0	0	0	0	0	104 (34.7)
<i>Tamias sibiricus</i> ^a	1	1	0	0	24	5	0	15	44
TOTAL	541	122	835	75	24	9	0	17	960

^a Collected by the Division of Vertebrates Research, Korea National Institute of Biological Resources (means not calculated).

^b Infestation rate = Total number sampled/Total number with ticks.

^c Mean number ticks = Total number ticks/Total number of small mammals with ticks.

This is the first record of *I. pomeranzevi* from *A. agrarius* in Korea. Two nymphs were collected from two *A. agrarius* (Aa-08-123 (male) and Aa-08-125 (female)) captured at Chipori Range (38° 08' 09" N, 127° 19' 12" E) near Chipo-ri, Galmal-eup, Cheorwon-gun, Gangwon Province (12 February 2008), and two females and two nymphs were removed from two *A. agrarius* (Aa-08-321 (male) and Aa-08-522 (female)) at Nightmare Range (38° 03' 13" N, 127° 21' 18" E) near Topyeong-ri, E-dong-myeon, Pocheon-si, Gyeonggi Province (12 March and 16 April 2008). In a separate small mammal survey conducted by the Korea National Institute of Biological Resources, 15 females, 5 nymphs, and 24 larvae of *I. pomeranzevi* were recovered from one *T. sibiricus* captured near Bidulginang Falls (38° 04' 47.2" N, 127° 13' 03.2" E), Daehoesan-ri, Yeongbuk-myeon, Pocheon-si, Gyeonggi Province (20 March 2008) (Table 3). One engorged female (collected 12 March 2008) was placed in a humidified vial (6 cm in diameter) containing plaster of Paris and charcoal and held at 24°C. Oviposition occurred 11 days after removal from *A. agrarius* and continued for 14 days, at which point the tick died (Fig. 2). A total of 1,372 eggs were produced, but their chorions collapsed, eventually becoming contaminated with mold.

TABLE 3. Numbers of ticks collected from small mammals at Chipori and Nightmare Ranges and Bidulginang Falls, northern Gyeonggi and Gangwon Provinces, Republic of Korea, 2008.

Month	Collection Sites	Host/Species	Small mammals collected	Small mammals w/ticks	<i>Ixodes nipponensis</i>				<i>Ixodes pomernanzevi</i>				
					Larvae	Nymphs	Larvae	Nymphs	Males	Females	TOTAL		
JAN	Nightmare Range	<i>Apodemus agrarius</i>	80	0	0	0	0	0	0	0	0	0	
		<i>Apodemus peninsulae</i>	1	0	0	0	0	0	0	0	0	0	
		<i>Micromys minutus</i>	4	0	0	0	0	0	0	0	0	0	
		<i>Myodes regulus</i>	7	0	0	0	0	0	0	0	0	0	
		<i>Crocodyra lasiura</i>	6	0	0	0	0	0	0	0	0	0	
FEB	Nightmare Range	<i>Apodemus agrarius</i>	9	0	0	0	0	0	0	0	0	0	
		<i>Myodes regulus</i>	1	0	0	0	0	0	0	0	0	0	
		<i>Crocodyra lasiura</i>	1	0	0	0	0	0	0	0	0	0	
		Chipori Range	<i>Apodemus agrarius</i>	72	1	0	0	0	2	0	0	2	2
			<i>Apodemus peninsulae</i>	1	0	0	0	0	0	0	0	0	0
<i>Micromys minutus</i>	2		0	0	0	0	0	0	0	0	0		
MAR	Nightmare Range	<i>Myodes regulus</i>	7	0	0	0	0	0	0	0	0	0	
		<i>Crocodyra lasiura</i>	6	0	0	0	0	0	0	0	0	0	
		<i>Apodemus agrarius</i>	97	1	0	0	0	1	0	1	2	2	
		<i>Microtus fortis</i>	3	0	0	0	0	0	0	0	0	0	
		<i>Micromys minutus</i>	1	0	0	0	0	0	0	0	0	0	
APR	Nightmare Range	<i>Myodes regulus</i>	4	0	0	0	0	0	0	0	0	0	
		<i>Crocodyra lasiura</i>	6	0	0	0	0	0	0	0	0	0	
		<i>Tamias sibiricus</i>	1	1	0	0	0	5	0	1.5	44	44	
		<i>Apodemus agrarius</i>	69	49	7	68	0	1	0	1	77	77	
		<i>Mus musculus</i>	2	0	0	0	0	0	0	0	0	0	
SEP	Nightmare Range	<i>Micromys minutus</i>	3	2	0	2	0	0	0	0	2	2	
		<i>Myodes regulus</i>	2	0	0	0	0	0	0	0	0	0	
		<i>Crocodyra lasiura</i>	7	0	0	0	0	0	0	0	0	0	
		<i>Apodemus agrarius</i>	77	65	724	5	0	0	0	0	729	729	
		<i>Crocodyra lasiura</i>	5	3	104	0	0	0	0	0	104	104	
NOV	Nightmare Range	<i>Apodemus agrarius</i>	54	0	0	0	0	0	0	0	0	0	
		<i>Mus musculus</i>	1	0	0	0	0	0	0	0	0	0	
		<i>Micromys minutus</i>	4	0	0	0	0	0	0	0	0	0	
		<i>Crocodyra lasiura</i>	8	0	0	0	0	0	0	0	0	0	
		TOTAL Percent (%)		541	122	835	75	24	9	0	17	960	960

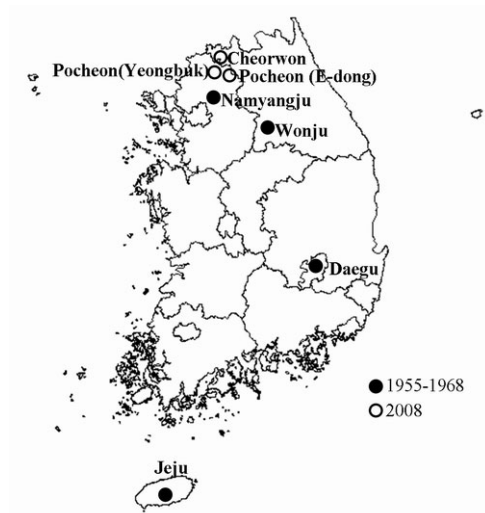


FIGURE 1. Map showing collection sites of *Ixodes pomaranzevi* described in this survey (○) and previous reports (●).

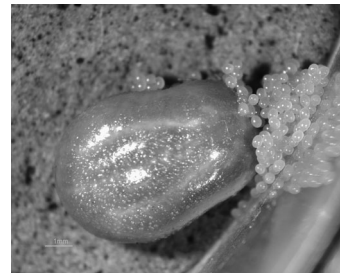


FIGURE 2. *Ixodes pomaranzevi* female ovipositing in a plaster of Paris/charcoal humidified chamber.

Discussion

With the exception of one *Haemaphysalis flava* Neumann, 1897, *I. nipponensis* was the sole tick species collected during surveys of > 4,000 small mammals using Sherman traps in northern Gyeonggi Province, near the DMZ, at elevations <50 m, accounting for 3,297 of 3,298 ticks collected from 2004 to 2007 (H.C. Kim, unpublished data). *Ixodes pomaranzevi*, an uncommonly collected tick, has been recorded during the late fall (October) through spring (May) months from Jeju Island and Wonju, Daegu, and Namyangju on the mainland (Robbins & Keirans 1992). Again, during our surveys, this species was found only from February through April in northern Gyeonggi and Gangwon Provinces, even though we collected through most of 2008. Also, previous U.S. military collection records of *I. pomaranzevi* are limited to specimens removed from small mammals (*M. regulus*, *T. triton*, and *T. sibiricus*) while conducting routine surveys at elevations >100 m. Interestingly, in Korea *I. pomaranzevi* has been collected exclusively from small mammals, rather than tick drags or other collection devices (Anonymous 1997; Ree 2005).

Further studies of the host relationships and geographic and seasonal distribution of *I. pomaranzevi* are necessary to better understand the biology of this obscure species and to define its role, if any, as a vector or reservoir of zoonotic pathogens.

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